

STANDARD TECHNICAL SPECIFICATION FOR SOIL INVESTIGATION

2.1.0 BORE HOLES

Drilling of bore holes of 150 mm dia. in accordance with the provisions of IS: 1892, to 15m depth or to refusal whichever occurs earlier. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. However, in case where deep pile foundations are envisaged, the depths have to be regulated as per codal provisions. In cases where rock is encountered, coring in bore holes shall be carried out to 3 M in bed rock and continuous core recovery is achieved.

Performing Standard Penetration Tests at approximately 1.5m intervals in the bore holes starting from 1.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests.

Collecting undisturbed samples of 100/75 mm diameter 450 mm long from the bore holes at intervals of 2.5m and every change of stratum starting from 1.0m below ground level onwards in clayey strata.

The depth of water table shall be recorded for each bore hole.

All samples, both disturbed and undisturbed, shall be identified properly with the bore hole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the borelog shall be handed over to the site representative of BHEL/Customer.

2.2.0 DYNAMIC CONE PENETRATION TEST

Dynamic cone penetration tests shall be carried out with the circulation of bentonite slurry at specified locations and a continuous record of penetration resistance (NG) up to 15.00m from natural ground level or the refusal shall be maintained by the Contractor. IS: 4968 (Part-2) shall be followed for carrying out the test and for reporting of results.

The location for the tests shall be as directed by BHEL/Customer. On completion of the test, the results shall be presented as a continuous record as the numbers of blows required for every 300 mm penetration of the cone into the soil.

2.3.0 TRIAL PITS

Trial pits shall be excavated at specified locations. The trial pits shall be 2m x 2m in size extending to 4m in depth, or as specified by BHEL/Customer. Undisturbed samples shall be taken from the trial pits as per the direction of the BHEL/Customer.

2.4.0 PLATE LOAD TEST

Plate load test shall be conducted to determine the bearing capacity, modulus of subgrade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to IS : 1888, Modulus of subgrade reaction shall be conducted as per IS: 9214. The location(s) and depth of the test shall be as specified by BHEL/Customer. (Depth shall be upto a maximum of 3.00m below the natural ground level).

Undisturbed tube samples shall be collected at 1.0 m and 2.5m depths from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken upto the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs Settlement shall be kept as specified in IS: 1888.

Backfilling of the pit shall be carried out as per the directions of the Owner. Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

2.5.0 FIELD CALIFORNIA BEARING RATIO TEST

This test shall be carried out to obtain the properties of soil required for the construction of roads. The equipments and accessories required for carrying out the test, test procedure, recording of observations and presentation of results shall conform to IS: 2720 part XXXI.

2.6.0 WATER SAMPLE

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

2.7.0 BACK FILLING OF BORE HOLES

On completion of each hole, the Contractor shall backfill all bore holes as directed by the BHEL/Customer. The backfill material can be the excavated material.

2.8.0 LABORATORY TESTS

2.8.1 The laboratory tests shall be carried out progressively during the field work after sufficient number of samples have reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

2.8.2 All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant I.S. Codes.

The following laboratory tests shall be carried out:

- (i) Visual and Engineering Classification.
- (ii) Liquid limit, plastic limit and shrinkage limit for C- ϕ soils.
- (iii) Natural moisture content, bulk density and specific gravity.
- (iv) Grain size distribution.
- (v) Swell pressure and free swell index determination.
- (vi) California bearing ratio.
- (vii) Consolidated drained test with pore pressure measurement.
- (viii) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.
- (ix) Rock quality designation (RQD), RMR in case when rock is encountered.

2.9.0 ELECTRICAL RESISTIVITY TESTS

2.9.1 This test shall be conducted to determine the electrical resistivity of soil required for designing safety grounding system for the entire sub-station area of 765kV and 400kV. The specification for the equipment and other accessories required for performing the test, test procedure and report-ing of field observations shall conform to IS: 3043. The test shall be conducted using Wenner's four electrode method as specified in IS: 1892, Appendix-B2. Unless otherwise specified, at each test location the test shall be conducted along two perpendicular lines parallel to the co-ordinate axes. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.5m upto a distance of 20m.

2.10.0 TEST RESULTS AND REPORTS

2.10.1 The Contractor shall submit the detailed report wherein information regarding the geological details of the site, summarized observations and test data, bore logs, and conclusions & recommendations on the type of foundations with supporting calculations for the recommendations are given. Initially, the report shall be submitted by the Contractor in draft form and after the draft report is approved, the final report in desired no. of copies shall be submitted. The test data shall bear the signatures of the contractor and site representative of BHEL/Customer.

2.10.2 The report shall include, but not limited to the following :

- (i) A plan showing the locations of the exploration work i.e. bore holes, dynamic cone penetration tests, trial pits, plate load test, etc.
- (ii) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.
- (iii) Test results of field and laboratory tests shall be summarized strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.
- (iv) Recommendations: The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from BHEL/Customer. The observations and recommendations shall include, but not limited to the following:

- (a)** Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.
- (b)** Recommended type of foundations for various structures. If piles are recommended, the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.
- (c)** Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 2.5/3.0(As advised by BHEL/Customer).
- (d)** Recommendation regarding liquefaction characteristics of soil.
- (e)** Recommendations regarding slope of excavations and dewatering schemes, if required.
- (f)** Comments on the chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.
- (g)** If expansive soil is met with, recommendations on removal or retainment of the same under the structure, road, drains, etc. shall be given. In the latter case detailed specification of any special treatment required including specification of materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.
- (h)** Recommendations for additional investigations beyond the scope of the present work, if considered necessary.